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Mediators of Socioeconomic Inequity in Living-donor Kidney Transplantation: Results From a UK Multicenter Case-Control Study

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Background. There is evidence of socioeconomic inequity in access to living-donor kidney transplantation, but limited evidence as to why. We investigated possible mediators of the inequity. **Methods.** This questionnaire-based case-control study included 14 UK hospitals. Participants were adults transplanted between April 1, 2013 and March 31, 2017. Living-donor kidney transplant (LDKT) recipients (cases) were compared with deceased-donor kidney transplant recipients (controls). We collected data on mediators identified in earlier qualitative work: perceived social support (Interpersonal Support Evaluation List shortened version-12), patient activation (Patient Activation Measure 13), and LDKT knowledge (Rotterdam Renal Replacement Knowledge Test). We performed mediation analyses to investigate what proportion of the effect of socioeconomic position (education and income) on case-control status was mediated by these variables. **Results.** One thousand two-hundred and forty questionnaires were returned (40% response). Receipt of an LDKT over a deceased-donor kidney transplant was associated with higher socioeconomic position [adjusted odds ratio (aOR) university degree versus no degree aOR = 1.48 (95% confidence interval [CI], 1.18-1.84), $P = 0.001$ and aOR per +£1000 increase in monthly household income after tax 1.14 (95% CI, 1.11-1.17), $P < 0.001$] higher perceived social support (aOR per +1-point Interpersonal Support Evaluation List shortened version-12 score = 1.05 (95% CI, 1.03-1.08), $P < 0.001$), higher levels of patient activation (aOR per +1 patient activation measure level = 1.35 (95% CI, 1.24-1.48), $P < 0.001$), and greater LDKT knowledge (aOR per +1-point Rotterdam Renal Replacement Knowledge Test score = 1.59 (95% CI, 1.49-1.69), $P < 0.001$). Mediation analyses revealed that perceived social support, patient activation, and LDKT knowledge together mediate 48.5% (95% CI, 12.7-84.3, $P = 0.008$) of the association between university education and LDKT status, and 46.0% (95% CI, 28.7-63.4, $P < 0.001$) of the association between income and LDKT status. **Conclusions.** LDKT knowledge, perceived social support, and patient activation are associated with the socioeconomic position of people with kidney disease, and mediate approximately 50% of the association between the socioeconomic position and receipt of an LDKT. Interventions that target these factors may redress observed socioeconomic inequity.

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Living-donor kidney transplantation offers the best treatment in terms of life-expectancy and quality of life^{1,2} for most people with kidney failure. In the United Kingdom, there

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are no direct costs to an individual receiving a kidney transplant or donating a kidney, and potential donors are entitled to reimbursement from NHS England for loss of earnings, travel and carer costs.³ Despite this reimbursement system in the United Kingdom, socioeconomic deprivation is associated with reduced access to living-donor kidney transplantation^{4,5}; individuals who have no educational qualifications are 45% less likely to receive a living-donor kidney transplant (LDKT) over a deceased-donor kidney transplant (DDKT) than those who have higher education qualifications.⁵ The same association has been demonstrated in the Netherlands,⁶ the United States,⁷ and Australia.⁸ A US Consensus Conference in 2014 on Best Practices in Live Kidney Donation concluded that the mechanisms behind these observed disparities must be understood to identify targets for intervention.⁹

This study is part of a mixed-methods program of research to understand why socioeconomically deprived people with kidney disease are less likely to receive an LDKT. We aimed to understand the reasons behind the observed socioeconomic inequity in access to living-donor kidney transplantation specifically, and not in access to transplantation in general.

Qualitative work identified that: (1) *passivity*, (2) *disempowerment*, and (3) *perceiving a lack of social support* were particularly important factors that prevented socioeconomically deprived individuals from accessing an LDKT.¹⁰ Qualitative interviews suggested that more socioeconomically deprived people with kidney failure are less involved in and less confident having discussion about their treatment, and they are less engaged in these discussion.¹⁰ This finding is consistent with research that has shown that more socioeconomically disadvantaged groups have lower levels of “patient activation,”¹¹ a metric describing the “knowledge, skills, and confidence a person has in managing their own health and healthcare.”¹² More socioeconomically deprived people also perceived a lack of social support and appeared to struggle to think of people who might be willing donors.¹⁰

We designed this questionnaire-based case-control study to further investigate and quantitatively evaluate our previous qualitative findings. We examined whether receipt of an LDKT was associated with: (1) an individual’s knowledge about living-donor kidney transplantation, (2) a person’s level of patient activation, and (3) the social support perceived by a person with kidney disease. We also investigated whether the above variables were associated with socioeconomic position within the control population of DDKTs. We then investigated the variables above as potential intermediaries in the causal pathway between socioeconomic deprivation and reduced odds of receiving an LDKT over a DDKT as these mediators might be more amenable to intervention than the socioeconomic position.

MATERIALS AND METHODS

Study Sites

The study was based at 14 hospitals in England and Northern Ireland: Belfast, Birmingham, Bristol, Cambridge, Epsom and St Helier, Guy’s and St Thomas’s, Imperial, Leicester, Manchester, Newcastle upon Tyne, Nottingham, Oxford, Sheffield, and St George’s.

Participants

We obtained from each hospital an anonymized list of all individuals who received kidney transplants between April 1,

2013 and March 31, 2017, stratified by LDKT and DDKT status. Individuals who were aged ≥ 18 years at the time of transplantation were eligible for participation. Individuals who lacked mental capacity according to the Mental Capacity Act 2005 were excluded. A person is defined as lacking capacity if they are unable to do 1 or more of the following: (1) understand information given to them, (2) retain that information long enough to be able to make a decision, (3) weigh up the information available to make the decision, and (4) communicate their decision. P.B. performed stratified random sampling using Stata 15¹³ to select on average 110 LDKTs and 110 DDKTs from each site, weighted by the number of transplants performed at each study site. Sex and 5-year age group strata matched sampling was used to try to ensure a similar sample distribution by age and sex. We calculated the study sample size using the patient activation variable.¹⁴ To detect a difference of 7 points between LDKT cases and DDKT controls (ie, 64 versus 57) at 90% power, 5% significance and a 1:1 ratio would require 85 subjects per group (170 total), and at least 850 if comparing across 5 socioeconomic strata/quintiles. A sample of 944 subjects would account for a predicted 10% missing data. This sample size allows detection of a far smaller difference (0.16 SD) for a dichotomous exposure or between 6% and 8% for a categorical outcome.¹⁴

Between October 2017 and November 2018, collaborators at study sites mailed paper questionnaires to participants. Questionnaires were accompanied by an invitation letter, a return postage paid envelope, and a patient information sheet outlining the potential risk and benefits of participating. Participants were advised that they may find the questionnaire-raised sensitive issues, and were offered an opportunity to discuss these further. We stated that taking part would not be of direct benefit, but that the information provided would help us to benefit other patients in the future. A website address was provided so that participants could complete the questionnaire online if preferred. Collaborators sent nonresponders a second questionnaire after 4–6 weeks. P.B. extracted anonymized data from returned paper questionnaires at the University of Bristol, and uploaded these onto a secure REDCap database.¹⁵

Questionnaire Content

We have previously reported questionnaire development and the findings of a single-center pilot study.¹⁴ As indicated in the introduction, original item generation was informed by themes arising from qualitative research¹⁰: (1) *passivity*, (2) *disempowerment*, and (3) *perceiving a lack of social support*. Written consent for the study was requested on the first page of the questionnaire.

Survey Tools

Social support was measured using the Interpersonal Support Evaluation List shortened version-12 items survey (ISEL-12).^{16–18} The ISEL-12 generates a total score (0–36) that describes overall perceived social support¹⁶; high scores indicate a greater level of perceived social support. The psychometric properties of the ISEL-12 have good validity and reliability, including in populations similar to our study population in terms of age, ethnicity and gender.^{17,18} Participants were asked to indicate the number of living relatives ≥ 18 years from a list (spouse/partner, parents, sisters/brothers, children, aunts/uncles, and first cousins) as a proxy

for potential living-donor pool. Friends and colleagues were not included, as they contribute very small numbers to the donor pool: between 2006 and 2017 only 8% of the UK living donors were in this category (unpublished data provided by NHS Blood and Transplant to the first author P.B.). Participants were asked about the reasons why they thought their relatives could not donate (from a list of reasons including age, health, weight, location, financial cost, blood group, job, no one to care for them after donation, and free-text entry).

LDKT knowledge (scored 0–10) was measured using the living donation subscale of the Rotterdam Renal Replacement Knowledge Test survey¹⁹ which provides a validated and reliable measure of a patient's knowledge of kidney disease and treatment options in clinic and research.²⁰ The questions were in True/False format and higher scores indicate a greater knowledge of living-donor kidney transplantation.

An individual's level of engagement in their health care was measured using Insignia Health's 13-point patient activation measure (PAM).¹² "Patient activation" is a behavioral concept that incorporates the themes emergent from the qualitative work of passivity, disempowerment, and limited knowledge. It is defined as "an individual's knowledge, skill, and confidence for managing their health and healthcare."¹² The measure has good psychometric properties.²¹ Higher PAM scores indicate higher patient activation. The raw score (maximum 100) can be converted into 4 activation levels: (1) not believing activation important, (2) a lack of knowledge and confidence to take action, (3) beginning to take action, and (4) taking action.

Participant Demographics

We collected data on age, sex, marital status, ethnicity, religion, and individual-level socioeconomic data including education level and income. Ethnicity was coded using the UK's Office for National Statistics 2011 census categories²²: White; Asian/Asian British (Indian, Pakistani, Bangladeshi, and Chinese); Black/African/Caribbean/Black British; Mixed/Multiple (White and Black Caribbean, White and Black African, Any other Mixed/Multiple ethnic background); and Others (Arab, Any other ethnic group).

Statistical Analysis

We used multivariable logistic regression to look at the association of receipt of an LDKT (case) compared with DDKT (control) with a recipient's socioeconomic position, perceived social support, patient activation, LDKT knowledge, and number of potential donors. We used 2 models: (1) unadjusted and (2) adjusted for potential confounders. We specified, a priori, potential confounders including sex, age, and ethnicity. For the model evaluating social support, the number of potential donors was included as a confounder. We used robust standard errors to account for clustering within renal centers. We tested for a priori interactions between the socioeconomic deprivation variables and age, sex, and ethnicity. We performed a complete case analysis and then undertook a sensitivity analysis using multiple imputation using chained equations to derive 40 imputed datasets per group, for the exposure variable and potential confounders and then combined using Rubin's rules using the multiple imputation procedure in Stata 15.¹³

Mediation Analyses

We undertook mediation analyses to quantitatively evaluate LDKT knowledge, patient activation, and social support as potential intermediaries in the causal pathway between socioeconomic deprivation and reduced odds of receiving an LDKT over a DDKT. Directed acyclic graphs illustrating possible mediation models are provided in Figure 1A–C. We aimed to decompose the association between socioeconomic position (exposure) and living-donor kidney transplantation (outcome) into the direct effect of the exposure on the outcome measure (*a*) and the indirect mediated effect across each of the 3 proposed mediator variables (*x*, *y* and *z*).

Mediation analyses were performed in Stata 15 using the `ldecomp` command which applies the analytic approach by Buis,²³ an extension of the decomposition method described by Eriksson et al²⁴ for logit models. This method allows assessment of the effect of multiple mediators in 1 model and for the adjustment of confounders. The analyses were run allowing for interactions between the exposure variables and mediators.

Variables as Mediators

It is possible that 2 of the proposed mediator variables (LDKT knowledge and perceived social support) might change as a result of receiving a LDKT rather than because they act as mediators. In this scenario, in contrast to the directed acyclic graphs in Figure 1A–C, higher socioeconomic position would be associated with an increased likelihood of an LDKT over a DDKT, and the receipt of an LDKT itself would cause an increase in a participant's LDKT knowledge and perceived social support ("reverse mediation"). However, this study is part of a mixed-methods program of research and follows on from previous qualitative research with people who had not received LDKT in which LDKT knowledge, perceived social support, and patient activation were identified as reasons for not receiving an LDKT. This qualitative study and subsequent quantitative questionnaire study together represent an exploratory sequential mixed methods design.²⁵ In this approach, elaboration, enhancement, and quantification of the results of 1 method are sought with the results from the other method.²⁶ The qualitative evidence is that these variables are mediators. In addition, before mediation analyses we investigated whether (1) LDKT knowledge, (2) patient activation, and (3) perceived social support were associated with socioeconomic position (exposure variable) within the control population of DDKTs. This demonstrated that socioeconomic position is associated with the mediators within the controls (SDC, <http://links.lww.com/TXD/A247>), which cannot be the result of receiving an LDKT. Higher socioeconomic position was associated with higher LDKT knowledge, greater levels of perceived social support, and greater patient activation within controls, who had not received the LDKT intervention (Tables S1–3, SDC, <http://links.lww.com/TXD/A247>). This provides quantitative evidence to support the first part of the mediation model in Figure 1A–C: that socioeconomic position is associated with the mediators before receipt of an LDKT.

While Human Leukocyte Antigen (HLA) sensitization is associated with access to transplantation in general, the Access to Transplantation and Transplant Outcome Measures (ATTOM) study found no evidence that HLA sensitization is related to likelihood of receiving an LDKT over a DDKT.⁵ There is evidence from the ATTOM study that Primary Renal

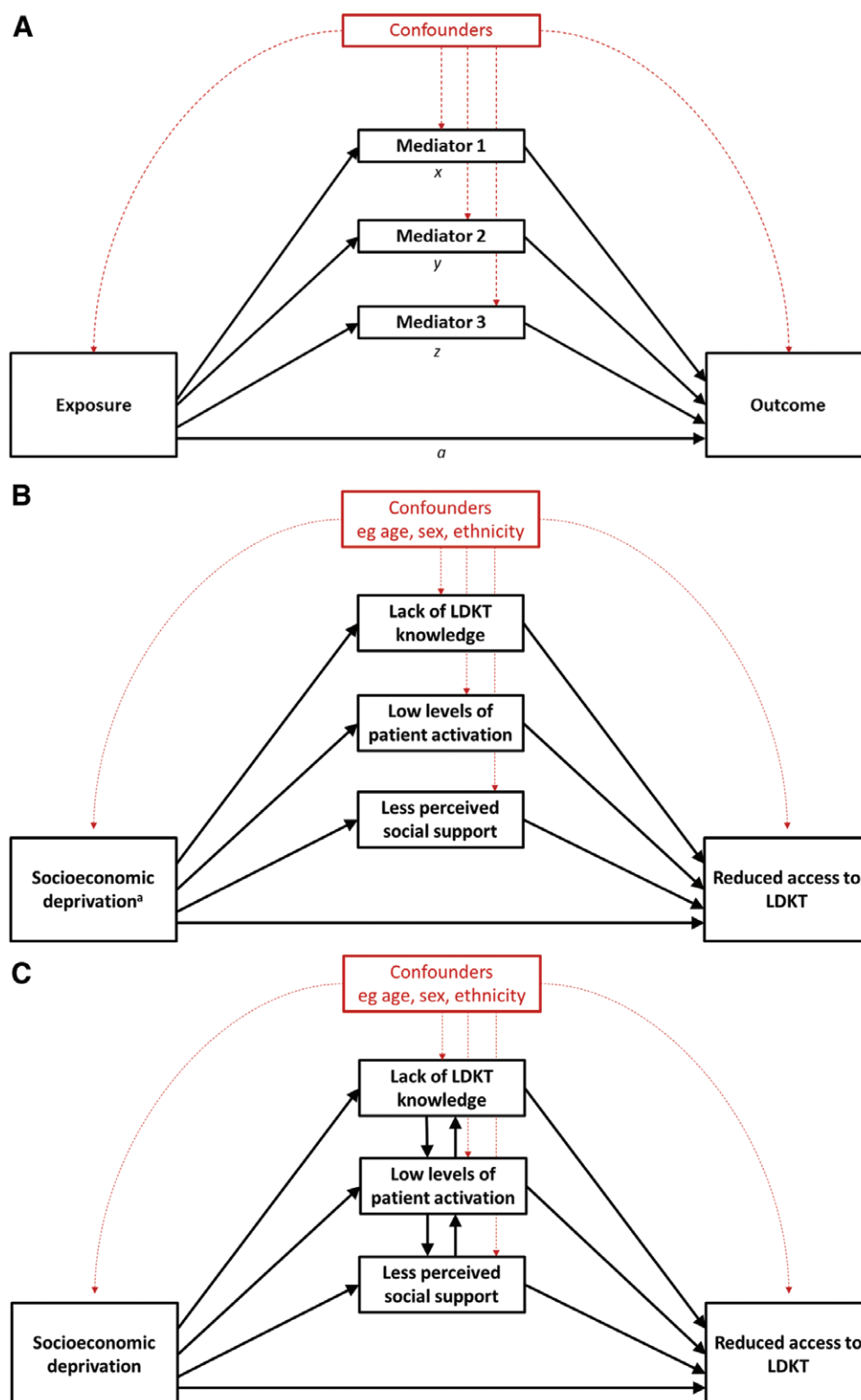


FIGURE 1. Mediation analyses models. A, Mediation model. B, This model assumes the multiple mediators are independent and that the mediated pathways are independent. C, This model allows mediator variables to affect other mediator variables. LDKT, living-donor kidney transplant.

Disease (PRD) can affect likelihood of LDKT over DDKT.⁵ When the incidence of specific diagnoses has been examined (eg, IgA nephropathy), associations with socioeconomic deprivation have been demonstrated.^{27,28} There is therefore some evidence to suggest that socioeconomic deprivation is associated with the development of specific PRDs, and that PRD can

affect the likelihood of an LDKT. PRD is therefore another potential mediator (not measured in this study due to reliance on self-report in this questionnaire design), but it is not a confounder. HLA sensitization and PRD are therefore not confounders of the association between socioeconomic position (exposure) and living-donor kidney transplantation (outcome).

We received NHS Research Ethics Committee (Research Ethics Committee reference 17/LO/1602) and Health Research Authority approval. The clinical and research activities reported are consistent with the Principles of the Declaration of Istanbul as outlined in the “Declaration of Istanbul on Organ Trafficking and Transplant Tourism.”

RESULTS

One thousand two-hundred forty questionnaires were returned from 3103 patients (40% response). Three thousand one-hundred seventy-two individuals were sampled from anonymized lists of kidney transplant recipients from 14 hospitals, but 69 questionnaires were not received due to the sampled participant: (1) dying (death occurring or being recorded after sampling), (2) moving house, (3) not having mental capacity as judged by a relative on receipt of the questionnaire, or (4) being a hospital inpatient. LDKT recipients were more likely to respond than DDKT recipients (46% versus 34%) and women were more likely to respond than men (43% versus 37%) (Table S4, SDC, <http://links.lww.com/TXD/A247>). However, respondents did reflect the transplant population from which they were sampled (Table S5, SDC, <http://links.lww.com/TXD/A247>).

Overall, the proportion of missing data was small (<10% for all variables except income for which it was 36%) (missing data). With respect to the income variable, no pattern of missingness was observed with ethnicity (χ^2 , $P = 0.90$) or transplant type (χ^2 , $P = 0.20$) but maybe with sex (χ^2 , $P = 0.003$) and age (χ^2 , $P = 0.001$). Women were more likely to have missing/blank data. There was the suggestion of a U-shaped curve with age, in that the oldest and youngest age groups were more likely to have missing/blank data (including “would rather not answer”).

No evidence of interaction between the socioeconomic deprivation measures and sex, age, ethnicity was found, nor between age and ethnicity, and age and sex. There was a suggestion of interaction between sex and ethnicity (likelihood ratio test, $P = 0.009$). In white people, 56%–59% of both DDKT and LDKT recipients were men, while in nonwhite people 70% of DDKT and 53% of LDKT recipients were men. However, the number of nonwhite people in the study was very small ($n = 171$ nonwhite participants compared with $n = 1026$ white participants).

Participant characteristics by case-control status are reported in Table 1. As expected, a greater proportion of recipients of DDKTs were from lower socioeconomic and nonwhite groups when compared to recipients of LDKTs.

Exposure Variables

As previously reported, people with higher socioeconomic position were more likely to receive a LDKT (Table 2):

- University education: University education versus no university education adjusted odds ratio (aOR) 1.48 [95% confidence interval (CI), 1.18–1.84], $P = 0.001$.
- Income: aOR per £1000 increase in salary OR 1.14 (95% CI, 1.11–1.17), $P < 0.001$.

Receiving an LDKT over a DDKT was associated with higher levels of social support [aOR per +1 ISEL-12 score 1.05 (95% CI, 1.03–1.08), $P < 0.001$], higher levels of patient

activation [aOR per +1 PAM level 1.35 (95% CI, 1.24–1.48), $P < 0.001$], and greater LDKT knowledge [aOR per +1 point R3K-T score 1.59 (95% CI, 1.49–1.69), $P < 0.001$] after adjusting for potential confounders (Table 2).

The number of potential donors available to an individual was associated with the likelihood of receiving an LDKT over a DDKT [aOR per +1 potential donor 1.03 (95% CI, 1.02–1.04), $P < 0.001$] (Table 2), but the effect appeared to be small.

Only 11% of participants ($n = 141$) reported that financial concerns for the donor were a reason that their relatives could not donate to them. There was weak evidence that financial concerns were associated with likelihood of having an LDKT (OR 0.64, 95% CI, 0.42–0.97, $P = 0.03$), but financial concerns were not associated with participant socioeconomic position (Table S6, SDC, <http://links.lww.com/TXD/A247>).

The associations did not significantly differ between the complete cases analysis and the analyses with missing variables imputed (Table S7, SDC, <http://links.lww.com/TXD/A247>).

Mediation Analyses

Using the method described by Buis,²³ we estimated the following: (1) the direct effect of socioeconomic position on receipt of an LDKT and (2) the indirect effect mediated through the 3 mediators under investigation (social support, patient activation, and LDKT knowledge) (Table 3).

The 3 mediator variables together mediate approximately 48.5% [(95% CI, 12.7–84.3), $P = 0.008$] of the association between university education and access to transplantation, and 46.0% [(95% CI, 28.7–63.4), $P < 0.001$] of the association between income and access to transplantation.

DISCUSSION

We have demonstrated that the modifiable factors of an individual's perceived social support, level of patient activation, and LDKT knowledge are associated with both the socioeconomic position of people with kidney disease and the receipt of an LDKT over a DDKT. We have also demonstrated that these variables may mediate approximately 50% of the well-described association between the socioeconomic position and receipt of an LDKT. This understanding suggests interventions that target these factors could improve access to living-donor kidney transplantation for socioeconomically disadvantaged individuals in the United Kingdom.

Social support and social networks are recognized as important social determinants of health.²⁹ Lack of social support has been associated with adverse health behavior and poor health outcomes, especially among individuals from areas of high socioeconomic deprivation^{30,31}; this study demonstrates this association among people with kidney disease.

While the perception of a lack of social support may reflect the accurate perception of a true lack of social support resulting from less strong social ties, it might indicate a misperception of the social support that is truly available to an individual, and therefore may be modifiable. A perceived lack of social support may deter individuals from engaging with their social network regarding possible living kidney donation, but recent research from the United States has also suggested that transplant providers exclude between 10% and 22% of transplant candidates from transplantation due to an assessment that they lack social support.³² Whether this judgment

TABLE 1.
Participant characteristics by case-control status^a

Characteristics		Controls (DDKTs); n = 565	Cases (LDKTs); n = 672	Chi2
Sex (%)	Male	322 (57.0)	382 (56.9)	$P = 0.95$
	Female	235 (41.6)	279 (41.5)	
	Missing	8 (1.4)	11 (1.5)	
Age in y (%)	20–29	27 (4.8)	47 (7.0)	$P = 0.44$
	30–39	57 (10.1)	80 (11.9)	
	40–49	102 (18.1)	106 (15.8)	
	50–59	153 (27.1)	178 (26.5)	
	60–69	132 (23.4)	167 (24.9)	
	70–79	75 (13.3)	75 (11.2)	
	80–89	4 (0.7)	2 (0.3)	
	Missing	15 (2.7)	17 (2.5)	
Ethnicity (%)	White	445 (78.8)	581 (86.5)	$P = 0.005$
	Asian/Asian British	41 (7.3)	38 (5.7)	
	Black/African/Caribbean/Black British	39 (6.9)	19 (2.8)	
	Mixed/multiple	5 (0.9)	5 (0.7)	
	Other	14 (2.5)	10 (1.5)	
	Missing	21 (3.7)	19 (2.8)	
Highest level of education	No formal education	10 (1.8)	7 (1.0)	$P = 0.037$
	Primary school	10 (1.8)	3 (0.45)	
	Secondary school	191 (33.8)	202 (30.1)	
	Vocational/technical	143 (25.3)	171 (25.5)	
	University—undergraduate	98 (17.4)	145 (21.6)	
	University—postgraduate	46 (8.1)	73 (10.9)	
	Other	24 (4.3)	33 (4.9)	
	Missing	43 (7.6)	38 (5.7)	
Monthly household income after tax	<£1000	76 (13.5)	32 (4.8)	$P < 0.001$
	£1000–£1999	113 (20.0)	97 (14.4)	
	£2000–£2999	68 (12.0)	100 (14.9)	
	£3000–£3999	41 (7.3)	83 (12.4)	
	£4000–£4999	17 (3.0)	41 (6.1)	
	£5000–£5999	15 (2.7)	33 (4.9)	
	£6000–£6999	7 (1.2)	19 (2.8)	
	>£7000	15 (2.7)	37 (5.5)	
	Missing	213 (37.7)	230 (34.2)	

^aThe 3 participants for whom transplant type/case-control status was missing are excluded from this table.
DDKT, deceased donor kidney transplant; LDKT, living-donor kidney transplant.

among healthcare professionals in the United Kingdom explains part of our observed association between social support and reduced access to an LDKT requires investigation.

A higher socioeconomic position was associated with a greater level of LDKT knowledge, which was associated with a greater odd of having an LDKT. However, in addition to information and knowledge, individuals require the confidence and skill to use this information, which is captured in the PAM.²¹ A recent cross-sectional survey from the United States found that how an individual *perceived* their transplant knowledge, and their confidence in this knowledge, was more important than their *actual* knowledge in pursuing an LDKT,³³ which indicates that the added element of confidence is important in receiving an LDKT. Further evidence to support this comes from a scoping review of interventions to increase numbers of LDKTs³⁴ which found that interventions of patient education alone did not result in an increase in the number of LDKTs.³⁴ Increasing transplant knowledge must also be accompanied by increasing confidence and skill in using this knowledge to increase uptake of LDKTs.

Transplant recipients have been reported to have higher levels of activation compared to people on dialysis,³⁵ but to

our knowledge, this is the first time LDKTs recipients have been shown to have higher levels of patient activation than DDKT recipients. Uncertainties remain as to how best to increase an individual's patient activation, and to what extent changes in patient activation result in improved clinical outcomes. Several studies have reported increases in patient activation in response to an intervention: these include tailored coaching,³⁶ 1-to-1 sessions and group discussion,³⁷ information sheets plus counseling,³⁸ and support preparing questions for a consultation.³⁹ Some studies have failed to show any change in PAM as a result of the intervention,³⁷ and only a small number of studies have demonstrated that increases in PAM change patient behavior or objective clinical outcomes, such as blood pressure.³⁶

Improving equity in living-donor kidney transplantation has been highlighted as a UK and international research priority by patients and clinicians.^{40,41} In this study, we have provided evidence of mediators of the socioeconomic inequity in living-donor kidney transplantation, and thus targets to intervention. A recent scoping review identified an important gap in the literature for evidence-based strategies to increase LDKTs.³⁴ The only intervention that has been shown to be

TABLE 2.**Logistic regression analysis: likelihood of receiving an LDKT over a DDKT findings^a**

Exposure variable	Unadjusted model; OR [95% CI]	Adjusted model ^b ; OR [95% CI]
Number of potential donors (per +1 potential donor)	1.03 [1.02–1.04]	1.03 [1.02–1.04]
PAM level (per +1 level in PAM)	1.37 [1.29–1.46]	1.35 [1.24–1.48]
Patient activation		
PAM level 1 (lowest)	Reference	Reference
PAM level 2	1.17 [0.75–1.81]	1.08 [0.67–1.74]
PAM level 3	1.87 [1.48–2.38]	1.81 [1.31–2.50]
PAM level 4 (highest)	2.39 [1.93–2.98] (<i>P</i> value for trend <0.001)	2.21 [1.65–2.97] (<i>P</i> value for trend <0.001)
Social support (per 1+ ISEL-12 score)	1.06 [1.04–1.09]	1.05 [1.03–1.08] ^c
LDKT knowledge (per 1+ point R3K-T score)	1.58 [1.48–1.67]	1.59 [1.49–1.69]
Education		
No university education	Reference	Reference
University level education	1.39 [1.12–1.74]	1.48 [1.18–1.84]
Income per +£1000 increase in monthly household income after tax	1.14 [1.12–1.17]	1.14 [1.11–1.17]

^aComplete case analysis.^bAdjusted for sex, age, ethnicity (binary).^cFor this analysis, a recipient's number of potential donors was also included as a confounder.

CI, confidence interval; DDKT, deceased donor kidney transplant; ISEL-12, Interpersonal Support Evaluation List shortened version-12; LDKT, living-donor kidney transplant; OR, odds ratio; PAM, patient activation measure; R3K-T, Rotterdam Renal Replacement Knowledge Test.

TABLE 3.**Total, direct, and indirect effects of socioeconomic position on receipt of an LDKT^{a,b}**

Measure of socioeconomic position	Total effect; OR [95% CI]	Direct effect; OR [95% CI]	Indirect effect via mediators; OR [95% CI]	% effect mediated by all 3 mediators (social support, patient activation, LDKT knowledge)
University education binary variable, <i>n</i> = 995	1.48 [1.18–1.86]	1.19 [0.97–1.46]	1.24 [1.13–1.37]	48.5 [12.7–84.3]
0—no university education	<i>P</i> = 0.001	<i>P</i> = 0.099	<i>P</i> < 0.001	<i>P</i> = 0.008
1—university education				
Income binary variable, <i>n</i> = 726	2.71 [2.09–3.51]	1.81 [1.34–2.45]	1.50 [1.30–1.73]	46.0 [28.7–63.4]
0—household income <£2000/mo	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001	<i>P</i> < 0.001
1—household income ≥£2000/mo				

^aComplete case analysis.^bAdjusted for sex, age, and ethnicity (binary).

CI, confidence interval; LDKT, living-donor kidney transplant; OR, odds ratio.

effective in randomized control trials is a home-based patient and family education approach.^{42,43} Developed and trialed among disadvantaged populations in the United States⁴² and the Netherlands.⁴³ Kidney patients and invited family members are visited at home by health workers who provide them with information on transplantation and donation, crucially engage the social network, and facilitate conversations about living kidney donation. The studies have reported a >20% increase in the number of LDKTs in the intervention versus control group.

Other home-based educational interventions are currently being evaluated in clinical trials, including the “Explore Transplant at Home” intervention in the United States.⁴⁴ Other promising interventions have not yet been formally evaluated in a clinical trial: the use of patient advocates has been evaluated in a small single-center US observational study.⁴⁵ In this intervention, a friend/relative/volunteer is trained as an advocate: someone willing to speak to other friends and family about LDKTs and donation on the patient's behalf, with resources available to share with the patient's social network. Although the study in the United States concentrated on advocating for patients in interactions with potential donors, this could be extended to advocate for patients in interactions with clinicians to help provide a “work-around” solution to low levels of patient activation.

This was a large, multicenter questionnaire-based case-control study. To our knowledge, this is the first study to look at social support, patient activation, and LDKT knowledge as mediators of the well-described socioeconomic inequity in living-donor kidney transplantation. The questionnaire used validated measures, no single-item measures were used, and before use the questionnaires were evaluated in cognitive interviews.¹⁴ The study used individual-level socioeconomic measures, and the proportion of missing data was small. However, this study has some limitations. First, although our response rate was reasonable for an unincentivized postal survey, and compared to the response rate of other postal surveys in the United Kingdom^{46,47} and the 47% response to a survey sent to Dutch and Swedish transplant recipients,⁴⁸ there is a risk of self-selection bias. Recipients of LDKTs were more likely to respond to the questionnaire, and individuals with greater patient activation, social support, LDKT knowledge, and higher socioeconomic position might be expected to be more likely to participate.¹⁴ This could introduce an artifactual association or affect the strength of a true association due to collider bias. However, this bias is only an issue if there is evidence of an interaction between exposure and outcome affecting response (or nonresponse)⁴⁹ which is not likely here. In addition, we also compared our findings to those from the ATTOM study (which had 72% participation), and found the

same effect sizes between socioeconomic position and likelihood of an LDKT (Table S8, SDC, <http://links.lww.com/TXD/A247>) providing further evidence, our sample is fairly representative of the total population of such patients. Second, 13.8% of participants were from Black, Asian and Minority Ethnic (BAME) groups: this is not a surprising finding as in the United Kingdom between 2013 and 2017 BAME individuals comprised 27% of DDKT recipients and 17% of LDKT kidney transplant recipients,⁵⁰ but study findings might not be transferrable to BAME groups. Third, the case-control design means it is impossible to prove causal associations between the variables explored and access to LDKTs. While reverse causation between living-donor kidney transplantation (over deceased-donor kidney transplantation) and socioeconomic position is not likely, recipients of LDKTs may have greater LDKT knowledge and perception of social support as a result of having an LDKT (“reverse mediation”). We do not believe that our findings are due to this effect for the following reasons. There is a priori evidence that the investigated variables do act as mediators (see above). Second, the observed socioeconomic differences observed in the control group would if anything be reduced if this was a secondary effect of receiving an LDKT, that is, lower socioeconomic recipients of an LDKT are more likely to increase their knowledge, for example, and hence this would actually attenuate the mediation effect we have observed rather than enhance it. For example, if the mediators were not associated with socioeconomic status, then adjustment would have no effect on the crude association between socioeconomic position and LDKT status. Finally, the strongest support for our findings comes from an intervention study from the Netherlands which demonstrated that increased knowledge and communication with one’s social network in disadvantaged renal patients increased numbers of LDKTs. This experimental evidence highlights the impact of altering these mediators and cannot be a consequence of receiving an LDKT.⁴³ We were unable to measure PRD, which, as noted above, may be another mediator that explains part of the unexplained association between socioeconomic position and living-donor kidney transplantation.

A lack of LDKT knowledge, perceived social support, and low levels of patient activation are associated with a reduced likelihood of having an LDKT. In addition, they appear to be potentially modifiable mediators of the socioeconomic inequity in access to LDKTs. Future interventions that target these factors may improve access to living-donor kidney transplantation for disadvantaged individuals in the United Kingdom.

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